PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

To:

Commissioner
US Department of Commerce
United States Patent and Trademark
Office, PCT
2011 South Clark Place Room
CP2/5C24
Arlington, VA 22202
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

Date of mailing (day/month/year) 21 March 2001 (21.03.01)	
International application No. PCT/US00/15734	**Applicant's or agent's file reference** CAS-004CIP
International filing date (day/month/year) 08 June 2000 (08.06.00)	**Priority date** (day/month/year) 08 June 1999 (08.06.99)
Applicant KATS, Vyacheslav D. et al	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

21 November 2000 (21.11.00)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland** Facsimile No.: (41-22) 740.14.35	Authorized officer Pascal Piriou Telephone No.: (41-22) 338.83.38

REPLACED BY

34

12

REC'D 08 JAN 2002
WIPO PCT

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference CAS-004CIP	**FOR FURTHER ACTION** See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/US00/15734	International filing date *(day/month/year)* 08 JUNE 2000	Priority date *(day/month/year)* 08 JUNE 1999
International Patent Classification (IPC) or national classification and IPC IPC(7): G01G 3/14 and US Cl.: 177/210R		
Applicant CIRCUITS AND SYSTEMS, INC.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 4 sheets.

   [✓] This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority. (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 1 sheets.

3. This report contains indications relating to the following items:

   - I [X] Basis of the report
   - II [ ] Priority
   - III [ ] Non-establishment of report with regard to novelty, inventive step or industrial applicability
   - IV [ ] Lack of unity of invention
   - V [X] Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI [ ] Certain documents cited
   - VII [ ] Certain defects in the international application
   - VIII [ ] Certain observations on the international application

Date of submission of the demand 21 NOVEMBER 2000	Date of completion of this report 26 MARCH 2001
Name and mailing address of the IPEA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer RANDY GIBSON Telephone No. (703) 308-1782

Deborah Perry-Leeper
Paralegal Specialist
Technology Center 2800

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/US00/15734

I. Basis of the report

1. With regard to the elements of the international application:*

☐ the international application as originally filed

☒ the description:
pages (See Attached), as originally filed
pages ______, filed with the demand
pages ______, filed with the letter of ______

☒ the claims:
pages (See Attached), as originally filed
pages ______, as amended (together with any statement) under Article 19
pages ______, filed with the demand
pages ______, filed with the letter of ______

☒ the drawings:
pages (See Attached), as originally filed
pages ______, filed with the demand
pages ______, filed with the letter of ______

☒ the sequence listing part of the description:
pages (See Attached), as originally filed
pages ______, filed with the demand
pages ______, filed with the letter of ______

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language ______ which is:

☐ the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).

☐ the language of publication of the international application (under Rule 48.3(b)).

☐ the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

☐ contained in the international application in printed form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ The statement that the information recorded in computer readable form is identical to the writen sequence listing has been furnished.

4. ☒ The amendments have resulted in the cancellation of:

☒ the description, pages NONE

☒ the claims, Nos. NONE

☒ the drawings, sheets/~~fig~~ NONE

5. ☐ This report has been drawn as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).**

** Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).*

***Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.*

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/US00/15734

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. statement

Novelty (N)	Claims	1-29	YES
	Claims	NONE	NO
Inventive Step (IS)	Claims	1-29	YES
	Claims	NONE	NO
Industrial Applicability (IA)	Claims	1-29	YES
	Claims	NONE	NO

2. citations and explanations (Rule 70.7)

Claims 1-29 meet the criteria set out in PCT Article 33(2)-(4), because the prior art does not teach or fairly suggest a piezoelectric surface acoustic wave load cell with hermetic seals nor anti-reflective structures.

------------------- NEW CITATIONS -------------------

NONE

Form PCT/IPEA/409 (Box V) (July 1998)*

Supplemental Box
(To be used when the space in any of the preceding boxes is not sufficient)

Continuation of: Boxes I - VIII

Sheet 10

I. BASIS OF REPORT:

This report has been drawn on the basis of the description,
page(s) 1-12, as originally filed.
page(s) NONE, filed with the demand.
and additional amendments:
NONE

This report has been drawn on the basis of the claims,
page(s) NONE, as originally filed.
page(s) NONE, as amended under Article 19.
page(s) NONE, filed with the demand.
and additional amendments:
Pages 13-21 filed with the letter of 13 November 2001

This report has been drawn on the basis of the drawings,
page(s) 1-6, as originally filed.
page(s) NONE, filed with the demand.
and additional amendments:
NONE

This report has been drawn on the basis of the sequence listing part of the description:
page(s) NONE, as originally filed.
pages(s) NONE, filed with the demand.
and additional amendments:
NONE

IMPROVED ELECTRONIC WEIGHING APPARATUS UTILIZING SURFACE ACOUSTIC WAVES

This application is a continuation-in-part of co-owned application Serial Number 08/729,752 filed October 7, 1996, now U.S. Patent Number 5,910,647, which was a continuation 08/489,365 filed June 12, 1995, now U.S. Patent Number 5,663,531, the complete disclosures of which are hereby incorporated by reference herein. The subject matter of these U.S. Patents can also be fount in WO 98/15803 published April 16, 1998.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to electronic weighing devices. More particularly, the invention relates to an electronic weighing device which employs surface acoustic waves to measure weight.

2. State of the Art

Precision electronic weighing devices are widely known in the art and there are many different technologies utilized in these electronic weighing devices. Laboratory scales or "balances" typically have a capacity of about 1,200 grams and a resolution of about 0.1 gram, although scales with the same resolution and a range of 12,000 grams are available. The accuracy of these scales is achieved through the use of a technology known as magnetic force restoration. Generally, magnetic force restoration involves the use of an electromagnet to oppose the weight on the scale platform. The greater the weight on the platform, the greater the electrical current needed to maintain the weight. While these scales are very accurate (up to one part in 120,000), they are expensive and very sensitive to ambient temperature. In addition, their range is relatively limited.

Most all other electronic weighing devices use load cell technology. In load cell scales, the applied weight compresses a column which has strain gauges bonded to its surface. The strain gauge is a fine wire which undergoes a change in electrical resistance when it is either stretched or compressed. A measurement of this change in resistance yields a measure of the applied weight. Load cell scales are used in non-critical weighing operations and usually have a resolution of about one part in 3,000. The maximum resolution available in a load cell scale is about one part in 10,000 which is insufficient for many critical weighing operations. However, load cell scales can have a capacity of several thousand pounds.

While there have been many improvements in electronic weighing apparatus, there remains a current need for electronic weighing apparatus which have enhanced accuracy, expanded range, and low cost.

Co-owned application Serial Number 08/489,365, previously incorporated by reference herein, discloses an electronic weighing apparatus having a base which supports a cantilevered elastic member upon which a load platform is mounted. The free end of the elastic member is provided with a first piezoelectric transducer and a second piezoelectric transducer is supported by the base. Each transducer includes a substantially rectangular piezoelectric substrate and a pair of electrodes imprinted on the substrate at one end thereof, with one pair of electrodes acting as a transmitter and the other pair of electrodes acting as a receiver. The transducers are arranged with their substrates substantially parallel to each other with a small gap between them and with their respective electrodes in relatively opposite positions. The receiver electrodes of the second transducer are coupled to the input of an amplifier and the output of the amplifier is coupled to the transmitter electrodes of the first transducer. The transducers form a "delay line" and the resulting circuit of the delay line and the amplifier is a positive feedback loop, i.e. a natural oscillator. More particularly, the output of the amplifier causes the first transducer to emit a surface acoustic wave ("SAW") which propagates along the surface of the first transducer substrate away from its electrodes. The propagating waves in the first transducer induce an oscillating electric field in the substrate which in turn induces similar SAW waves on the surface of the second transducer substrate which propagate in the same direction along the surface of the second transducer substrate toward the electrodes of the second transducer. The induced waves in the second transducer cause it to produce an alternating voltage which is supplied by the electrodes of the second transducer to the amplifier input. The circuit acts as a natural oscillator, with the output of the amplifier having a particular frequency which depends on the physical characteristics of the transducers and their distance from each other, as well as the distance between the respective electrodes of the transducers.

When a load is applied to the load platform, the free end of the cantilevered elastic member moves and causes the first transducer to move relative to the second transducer. The movement of the first transducer relative to the second transducer causes a change in the frequency at the output of the amplifier. The movement of the elastic member is proportional to the weight of the applied load and the frequency and/or change in frequency at the output of the amplifier can be calibrated to the displacement of the elastic member. The frequency response of the delay line is represented by a series of lobes. Each mode of oscillation is defined as a frequency where the sum of the phases in the oscillator is an integer multiple of 2π. Thus, as the frequency of the oscillator changes, the modes of oscillation move through the frequency response curve and are separated from each other by a phase shift of 2π. The mode at which the

oscillator will oscillate is the one having the least loss. The transducers are arranged such that their displacement over the weight range of the weighing apparatus causes the oscillator to oscillate in more than one mode. Therefore, the change in frequency of the oscillator as plotted against displacement of the transducers is a periodic function. There are several different ways of determining the cycle of the periodic function so that the exact displacement of the elastic member may be determined. In addition, in order to minimize the possibility that the oscillator will oscillate in two modes at the same time, the frequency response of the delay line is arranged so that no more than two modes coexist in the main lobe of the frequency response curve. This is achieved by the topology of the electrodes as well as the distance between the transmitting electrode and the receiving electrode. The gain of the amplifier is also chosen to be at least the absolute value of the greatest loss expected to be encountered at an oscillating frequency within the main lobe but not great enough to allow oscillation in two modes simultaneously.

According to a disclosed preferred embodiment, the surface acoustic wave has a wavelength of approximately 200 microns at 20 MHz. The gap between the substrates of the first and second transducers is as small as possible and preferably is less than 0.1 wavelength, i.e. 10-20 microns. The amplifier preferably has a gain of at least approximately 17 dB in order to guarantee natural oscillation, and preferably not more than approximately 30 dB so that the oscillator oscillates in only one mode at a time. The preferred manner of determining the cycle of the periodic output of the amplifier is to provide a second pair of transducers adjacent to the first pair and coupled to each other in the same type of delay line feedback loop. The second pair of transducers utilize a SAW with a different wavelength than the first pair of transducers, e.g. approximately 220 microns at 18 MHz. The output of the second amplifier is, therefore, a periodic function with a different frequency than the periodic function which is the output of the first amplifier. By combining the outputs of both amplifiers, a unique value is provided for each position of the elastic member.

Typically, the elastic member is chosen so that it will bend up to 150 microns under maximum load. Given the wavelength of the SAW, this results in about two to three modes of oscillation in the output of the first amplifier.

The provided apparatus can theoretically achieve an accuracy on the order of one part in one hundred thousand, e.g. one gram per hundred kilograms. In practice, however, a resolution on the order of one part in fifty thousand is readily achieved. It has been observed by the inventors herein that several factors have varying influence on the accuracy of the SAW system. These factors include reflected waves, temperature changes, and the frequency of the oscillator. Generally, reflected waves result in non-linearity of measurements, and temperature has an effect of about 70 ppm per degree C.

SUMMARY OF THE INVENTION

It is therefore an object of the invention to provide an electronic weighing apparatus which is accurate.

It is also an object of the invention to provide an electronic weighing apparatus which uses surface acoustic waves and is accurate over a broad range of weights.

It is another object of the invention to provide an electronic weighing apparatus which is compact and easy to construct.

It is a further object of the invention to provide an electronic weighing apparatus which is inexpensive to manufacture.

It is another object of the invention to provide an electronic weighing apparatus which utilizes surface acoustic waves and which is provided with means for reducing reflected waves.

It is still another object of the invention to provide an electronic weighing apparatus which maintains accuracy despite temperature gradients within the system.

It is yet another object of the invention to provide an electronic weighing apparatus which utilizes surface acoustic waves at a relatively high frequency.

In accord with these objects which will be discussed in detail below, the improved weighing apparatus of the present invention includes a base which supports a cantilevered elastic member upon which a load platform is mounted. The interior of the elastic member is hollowed and is provided with first and second piezoelectric transducers which are mounted on respective opposed posts. Each transducer includes a substantially rectangular piezoelectric substrate and a pair of electrodes imprinted on the substrate at one end thereof, with one pair of electrodes acting as a transmitter and the other pair of electrodes acting as a receiver. The transducers are arranged with their substrates substantially parallel to each other with a small gap between them and with their respective electrodes in relatively opposite positions. The receiver electrodes of the second transducer are coupled to the input of an amplifier and the output of the amplifier is coupled to the transmitter electrodes of the first transducer. The transducers form a "delay line" and the resulting circuit of the delay line and the amplifier is a positive feedback loop, i.e. a natural oscillator. More particularly, the output of the amplifier causes the first transducer to emit a surface acoustic wave ("SAW") which propagates along the surface of the first transducer substrate away from its electrodes. The propagating waves in the first transducer induce an

oscillating electric field in the substrate which in turn induces similar SAW waves on the surface of the second transducer substrate which propagate in the same direction along the surface of the second transducer substrate toward the electrodes of the second transducer. The induced waves in the second transducer cause it to produce an alternating voltage which is supplied by the electrodes of the second transducer to the amplifier input. The circuit acts as a natural oscillator, with the output of the amplifier having a particular frequency which depends on the physical characteristics of the transducers and their distance from each other, as well as the distance between the respective electrodes of the transducers.

According to the invention, when a load is applied to the load platform, the cantilevered elastic member bends and causes the first transducer to move relative to the second transducer. The movement of the first transducer relative to the second transducer causes a change in the frequency at the output of the amplifier. The bending movement of the elastic member is proportional to the weight of the applied load and the frequency and/or change in frequency at the output of the amplifier can be calibrated to the displacement of the elastic member.

According to one aspect of the invention, one or both substrates are provided with anti-reflection structure which may be an angled cut, a rounded end, or a surface damper.

According to a second aspect of the invention, the transducers are arranged on overlapping substrates which allows more room for a damping material to further reduce reflection and allows more room for additional transducers.

According to a third aspect of the invention, the transducers are coupled to a thermal sink to reduce the effects of thermal gradients across the transducers.

According to a fourth aspect of the invention, two pairs of transducers are provided and arranged to move in opposite directions which doubles the readability of measurements and also compensates for the effects of temperature gradients.

According to a fifth aspect of the invention, a thermal transducer channel is provided on the same substrate to measure the effects of temperature and thereby compensate for temperature effects.

According to a sixth aspect of the invention, a pair of differential transducers is arranged to measure the effects of temperature changes in the same acoustic channel in which displacement measurements are made.

According to a seventh aspect of the invention, a phase shift (preferably 180°) is introduced in the oscillator of the delay line, when required, in order for the oscillator to oscillate in the most optimal section of the frequency response curve (near the center) where temperature effects are minimized.

According to an eighth aspect of the invention, two surface dampers are provided for each transducer. This is accomplished in one of two ways. According to one way, a surface mount damper is formed from a thin mylar film. According to the other way, a multistrip coupler is formed by an aluminized pattern of lines behind the transducer and a surface damper is provided behind the multistrip coupler.

According to a ninth aspect of the invention, long term stability is enhanced by sealing the transducer, preferably hermetically, and/or by providing a second hermetically sealed temperature transducer and by using the output of the sealed transducer to correct for the effects of temperature and humidity.

Additional objects and advantages of the invention will become apparent to those skilled in the art upon reference to the detailed description taken in conjunction with the provided figures.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic side elevation view of an exemplary embodiment of the invention;

Figure 1a is an enlarged schematic plan view of a first transducer;

Figure 1b is an enlarged schematic plan view of a second transducer;

Figure 2 is a schematic diagram of a positive feedback loop with phase shifting according to the invention;

Figure 3 is an enlarged schematic plan view of a transducer according to the invention illustrating the propagation of SAW waves;

Figure 4 is a schematic transparent view of two transducers of the type shown in Figure 3 in operative alignment;

Figure 5 is an enlarged schematic side elevation view of the transducer system of Figure 4;

Figure 6 is a view similar to Figure 3 showing one embodiment of a transducer with two surface dampers;

Figure 7 is a view similar to Figure 3 showing another embodiment of a transducer with two surface dampers;

Figure 8 is a view similar to Figure 4 showing two of the transducers of Figure 7 in operative alignment;

Figure 9 is a view similar to Figure 1 illustrating one way of sealing the transducers; and

Figure 10 is a view similar to Figure 1 illustrating another way of sealing the transducers.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to Figures 1, 1a, and 1b, an electronic weighing apparatus 10 according to the invention includes a base 12 which supports a cantilevered elastic member 14 having a cut-out 15, and upon which a load platform 16 is mounted. The cut-out 15 is provided with two opposed posts 17, 19 upon which are respectively mounted a first piezoelectric transducer 20 and a second piezoelectric transducer 22. The posts 17, 19 serve to locate the transducers 20, 22 at the center of the elastic member 14 and to mechanically couple the transducers to opposite ends of the elastic member 14.

The first transducer 20 includes a substantially rectangular piezoelectric substrate 20a and a pair of electrodes 20b imprinted on the substrate at the upper end thereof. The second transducer 22 includes a substantially rectangular piezoelectric substrate 22a and a pair of electrodes 22b imprinted on the substrate at the lower end thereof. The substrates are preferably made of Lithium Niobate. The transducers are arranged with their substrates substantially parallel to each other with a small gap "g" between them. The electrodes 22b of the second transducer 22 are coupled to the input of an amplifier (not shown) powered by a power source (not shown) and the output of the amplifier is coupled to the electrodes 20b of the first transducer 20. The circuit arrangement is the same as shown in the parent application Serial Number 08/489,365, previously incorporated herein by reference. The resulting circuit is a positive feedback loop natural oscillator, a "delay line". The output of the amplifier generates an alternating voltage in the electrodes 20b of the first transducer 20 which generates a surface

acoustic wave ("SAW") 26 which propagates along the surface of the first transducer substrate 20a away from its electrodes 20b. Since the substrate 20a of the first transducer 20 is relatively close to the substrate 22a of the second transducer 22, an oscillating electric field which is induced as a result of the SAW waves 26 in the piezoelectric substrate 20a is able to in turn induce similar SAW waves 28 on the surface of the second transducer substrate 22a which propagate in the same direction along the surface of the second transducer substrate toward the electrodes 22b of the second transducer 22. The induced waves 28 in the second transducer 22 cause the electrode 22b of the second transducer 22 to produce an alternating voltage which is provided to the input of the amplifier. As long as the gain of the amplifier 24 is larger than the loss of the system, the circuit acts as a natural oscillator with the output of the amplifier having a particular frequency which depends on the physical characteristics of the transducers and their distance from each other, as well as the distance between the respective electrodes of the transducers. In particular, the frequency of the oscillator is directly related to the time it takes for the SAW to propagate from the electrodes 20b to the electrodes 22b.

According to presently preferred embodiments of the invention, described in more detail below, the SAW 26 has a wavelength of approximately 100-200 microns at 20-50 MHz. In order to limit loss in the system, the gap "g" between the substrates of the first and second transducers is as small as possible and preferably no more than 0.1 wavelength. In one preferred embodiment described below, the gap is 5-10 microns. With such a gap, an oscillating system can typically be generated if the amplifier 24 has a gain of at least approximately 17 dB. It will be appreciated that when a load (not shown) is applied to the load platform 16, the free end of the cantilevered elastic member 14 moves down and causes the second transducer 22 to move relative to the first transducer 20. In particular, it causes the electrodes 22b of the second transducer 22 to move away from the electrodes 20b of the first transducer 20. This results in a lengthening of the "delay line". The lengthening of the delay line causes an decrease in the frequency at the output of the amplifier. The displacement of the elastic member is proportional to the weight of the applied load and the frequency or decrease in frequency at the output of the amplifier can be calibrated to the distance moved by the elastic member.

It will be appreciated that locating the transducers at the center of the elastic member compensates for any torque on the member which would exhibit itself at the free end of the member. This results in an improved accuracy as compared to the weighing instrument of the parent application. Depending on the application (e.g. maximum load to be weighed), the elastic member is made of aluminum or steel. The presently preferred elastic member exhibits a maximum displacement of 0.1 to 0.2 mm at maximum load.

Referring now to Figure 2, a simplified delay loop according to the invention includes a first transducer 920, a second transducer 922, a first differential amplifier 950, a second differential amplifier 952, a pair of matching transformers 954, 956, a frequency counter and amplifier controller 958, and an output processor and weight display 960. The first transducer 920 includes a piezoelectric substrate 920a and electrodes 920b. The second transducer 922 includes a piezoelectric substrate 922a and electrodes 922b. The electrodes 920b are coupled via the matching transformer 954 to the inputs of the differential amplifiers 950, 952 in a parallel manner. The electrodes 922b are coupled to the outputs of the amplifiers 950, 952 via the matching transformer 956. As shown in Figure 2, the polarity of the outputs of the amplifier 950 is opposite to the polarity of the outputs of the amplifier 952. In addition, the enable input of each amplifier is coupled to the frequency counter and amplifier controller 958 which is also coupled to the outputs of the amplifiers. According to the invention, the amplifiers 950, 952 are turned on at one time by the frequency counter and amplifier controller 958. It will be appreciated that the phase of the outputs of the amplifiers differs by 180° or π. Thus, in order to apply or remove a phase shift, one of the amplifiers is turned off and the other is turned on. Those skilled in the art will appreciate that other circuits can be utilized to produce substantially the same type of phase shifting and that the circuit of Figure 2 is merely one example. According to the example shown in Figure 2, the frequency counter and amplifier controller 958 monitors the output of the amplifier 950 and detects when the frequency passes beyond the optimal gain area as described above, e.g., increases by 100Khz. When the frequency increases by a preselected amount, the frequency counter and amplifier controller 958 turns off amplifier 950 and turns on amplifier 952. The frequency counter and amplifier controller 958 then monitors the output of amplifier 952. After the frequency increases by an additional preselected amount, e.g. 100Khz, the frequency counter and amplifier controller 958 turns off amplifier 952 and turns on amplifier 950. While the frequency counter and amplifier controller 958 is monitoring frequencies, the frequencies are passed to the output processor and weight display 960 which analyzes the frequency of oscillation, correlates the frequency with a particular weight according to the methods described in the parent application, and displays the weight.

From the foregoing, as well as from the previously incorporated disclosures, those skilled in the art will appreciate that methods other than the counting of the frequency of the oscillator of the circuit of Figure 2 can be used to measure displacement and thus weight. For example, a circuit which measures period (the reciprocal of frequency), or a circuit which measures wavelength (period times the speed of propagation) could also be used according to the invention to measure weight. Moreover, a circuit which measures phase shift could also be used according to the invention to measure displacement and thus weight. Further, from the foregoing, as well as from the previously incorporated disclosures, those skilled in the art will

appreciate that it may be desirable to measure phase shift to determine the mode of oscillation directly as well as one of frequency, period, or wavelength to determine weight within that mode.

Turning now to Figures 3-5, those skilled in the art will appreciate that the transducers, e,g, transducer 1020 in Figure 3 propagate SAW waves in several directions. In a transducer having a so-called "uni-directional topology", a primary SAW wave 1026 is propagated by the electrodes 1020b toward the edge 1020c and is damped by the anti-reflection damper 1020e as described above. Another, albeit lower amplitude SAW wave 1026a is propagated in the opposite direction toward edge 1020d. It is desirable that additional anti-reflection damping be provided for this wave also. However, as can be seen from Figures 4 and 5, there is no room between the transducers 1020 and 1022 to provide dampers like 1020e and 1022e while still maintaining the close spacing between the transducers. Figure 6 shows one solution to the problem.

As shown in Figure 6, the transducer 1120 is provided with a thin anti-reflection damper 1120f between the electrodes 1120b and the edge 1120d. The damper 1120f is made from a layer of MYLAR which is approximately three microns thick. The MYLAR is glued to the substrate 1120a. One disadvantage of this solution is that the glue used to affix the MYLAR is approximately seven microns thick. The resulting thickness of approximately ten microns is too thick to maintain the optimal close spacing desired between two transducers. One alternative is to deposit a layer of silicon oxide or other similar material in place of MYLAR. A different solution is shown in Figures 7 and 8.

The transducer 1220 shown in Figure 7 is provided with a multistrip coupler 1220g and an anti-reflection damper 1220h which is similar in size to the damper 1220e. The coupler 1220g is made from an aluminized pattern which is printed on the substrate 1220a and which is designed to redirect SAW waves from the electrodes 1220b toward the damper 1220h. According to a presently preferred embodiment, the coupler includes one hundred parallel lines spaced with a period of approximately 0.7 times the wavelength of the SAW waves. Those skilled in the art will appreciate that types of couplers, using different patterns, can achieve similar results.

As shown in Figure 8, the arrangement of Figure 7 allows the close placement of two transducers 1220 and 1222 with relatively thick dampers 1220e, 1220h, 1222e, 122h while maintaining a close spacing between the substrates 1220a, 1222a.

As mentioned above, in order to assure good long term stability, it is desirable that the transducers be sealed. Turning now to Figure 9, a weighing apparatus 110 is similar to the apparatus 10 shown in Figure 1 with similar reference numerals (increased by 100) referring to similar structure. As shown in Figure 9, transducers 620, 622 (having on board temperature sensors) are sealed by providing a sealing box 102 which covers the entire elastic member 114. A rolling diaphragm 104 permits movement of the elastic member 114 and the load platform 116 relative to the box 102.

Another way to seal the transducers is shown in Figure 10 which illustrates a weighing apparatus 210 similar to the apparatus 10 shown in Figure 1 with similar reference numerals (increased by 200) referring to similar structure. According to this embodiment, a flexible sleeve 202 is placed over the transducers 620, 622 and sealed to the posts 217, 219. The sleeve may be made of a light weight LATEX or similar material. It will be appreciated that other methods of sealing the transducers can yield similar results.

As mentioned above, the effects of temperature and long term degradation can be further corrected by providing a separate hermetically sealed SAW temperature sensor (which senses change in temperature as a change in frequency) in addition to the temperature sensors on board the transducers in the elastic member. This is particularly useful if the temperature sensors on board the transducers in the elastic member are not hermetically sealed or if the seal (102, 202) is not perfectly hermetic. According to this aspect of the invention, two weight corrections can be made based on the temperature sensed by the hermetically sealed unit. As shown in Equation 1, the effects of temperature on the elastic member (114, 214) can be compensated for to yield a corrected weight Wc from a non-corrected weight Wn based on the temperature To in °C of the hermetically sealed transducer at the time the weight is measured and the temperature Tc in °C of the hermetically sealed transducer at the time the unit was calibrated.

$$Wc = Wn + (Wn * (Tc - To) * (55 \times 10^{-5}) \qquad (1)$$

The constant 55×10^{-5} is based on a Youngs modulus as well as other parameters for a particular aluminum elastic member. Other elastic members will require a different constant. It will be appreciated that Equation 1 may be implemented using any highly accurate temperature sensor. As shown in Equation 2, long term effects (such as absorption of water vapor and other degradation effects due to incomplete sealing) on the weight measuring transducer can be compensated for to yield a corrected weight Wc based on the uncorrected weight Wn, the reading Th (in Mhz) sensed by the hermetically sealed transducer, and the reading Tn (in Mhz) sensed by the non-sealed temperature sensor, where fc is the center frequency (in Mhz) for both sensors.

$$Wc = Wn - (Wn * \frac{Th - Tn}{fc}) \qquad (2)$$

There have been described and illustrated herein several embodiments of an electronic weighing apparatus utilizing surface acoustic waves. While particular embodiments of the invention have been described, it is not intended that the invention be limited thereto, as it is intended that the invention be as broad in scope as the art will allow and that the specification be read likewise. Thus, while particular geometries of the base, elastic member, and load platform have been disclosed, it will be appreciated that other geometries could be utilized. Also, while particular wavelengths have been disclosed, it will be recognized that other wavelengths could be used with similar results obtained. As mentioned above, rather than measuring frequency, period, wavelength or phase may be measured to determine weight. Measuring one of these other characteristics can help in high speed weighing, e.g. twenty readings or more per second. Moreover, while particular configurations have been disclosed in reference to the location of transmitting and receiving electrodes, it will be appreciated that the respective locations of transmitters and receivers could be reversed. Furthermore, while several different aspects of the invention have been disclosed as solving various problems, it will be understood that the different aspects of the invention may be used in combination with each other in configurations other than those shown. It will therefore be appreciated by those skilled in the art that yet other modifications could be made to the provided invention without deviating from its spirit and scope as so claimed.

Claims:

1. An electronic weighing apparatus, comprising:

a) a displaceable elastic member means for receiving a load and being displaced by the load such that the displacement of said elastic member means is related to the weight of the load;

b) a first piezoelectric transducer having a first substrate and a first surface acoustic wave (SAW) transmitter, said first piezoelectric transducer being coupled to said elastic member;

c) a second piezoelectric transducer having a second substrate and a first SAW receiver, said second piezoelectric transducer being mounted in close proximity to said first piezoelectric transducer such that said displacement of said elastic member causes a corresponding displacement of one of said first and second piezoelectric transducers relative to the other;

d) a first amplifier having an input and an output, said input of said first amplifier being coupled to said first SAW receiver and said output of said first amplifier being coupled to said first SAW transmitter such that said first piezoelectric transducer, said first amplifier, and said second piezoelectric transducer form a first circuit having a first output;

e) processor means coupled to said output of said first amplifier; and

f) sealing means covering said first and second piezoelectric transducers for sealing out moisture and other contaminants, wherein

displacement of said elastic member means causes a displacement of one of said first and second piezoelectric transducers relative to the other and thereby changes said first output, and one of frequency, period, wavelength, and phase shift of said first output is used by said processor means to determine an indication of the weight of the load.

2. An electronic weighing apparatus according to claim 1, wherein:

said sealing means is an hermetic seal.

3. An electronic weighing apparatus according to claim 1, wherein:

said sealing means is a flexible sleeve.

4. An electronic weighing apparatus, comprising:

a) a displaceable elastic member means for receiving a load and being displaced by the load such that the displacement of said elastic member means is related to the weight of the load;

b) a first piezoelectric transducer having a first substrate and a first surface acoustic wave (SAW) transmitter, said first piezoelectric transducer being coupled to said elastic member;

c) a second piezoelectric transducer having a second substrate and a first SAW receiver, said second piezoelectric transducer being mounted in close proximity to said first piezoelectric transducer such that said displacement of said elastic member causes a corresponding displacement of one of said first and second piezoelectric transducers relative to the other;

d) a first amplifier having an input and an output, said input of said first amplifier being coupled to said first SAW receiver and said output of said first amplifier being coupled to said first SAW transmitter such that said first piezoelectric transducer, said first amplifier, and said second piezoelectric transducer form a first circuit having a first output;

e) processor means coupled to said output of said first amplifier; and

f) an hermetically sealed temperature sensor having an output coupled to said processor means, wherein

displacement of said elastic member means causes a displacement of one of said first and second piezoelectric transducers relative to the other and thereby changes said first output, and one of frequency, period, wavelength, and phase shift of said first output is used by said processor means to determine an indication of the weight of the load and said processor means uses said output of said hermetically sealed temperature sensor to compensate for the effects of temperature on said output of said first circuit.

5. An electronic weighing apparatus, comprising:

a) a displaceable elastic member means for receiving a load and being displaced by the load such that the displacement of said elastic member means is related to the weight of the load;

b) a first piezoelectric transducer having a first substrate and a first surface acoustic wave (SAW) transmitter, said first piezoelectric transducer being coupled to said elastic member;

c) a second piezoelectric transducer having a second substrate and a first SAW receiver, said second piezoelectric transducer being mounted in close proximity to said first piezoelectric transducer such that said displacement of said elastic member causes a corresponding displacement of one of said first and second piezoelectric transducers relative to the other;

d) a first amplifier having an input and an output, said input of said first amplifier being coupled to said first SAW receiver and said output of said first amplifier being coupled to said first SAW transmitter such that said first piezoelectric transducer, said first amplifier, and said second piezoelectric transducer form a first circuit having a first output; and

e) processor means coupled to said output of said first amplifier, wherein

one of said first and second piezoelectric transducers is provided with two anti-reflection structures to minimize reflection of surface acoustic waves, and

displacement of said elastic member means causes a displacement of one of said first and second piezoelectric transducers relative to the other and thereby changes said first output, and one of frequency, period, wavelength, and phase shift of said first output frequency is used by said processor means to determine an indication of the weight of the load.

6. An electronic weighing apparatus according to claim 5, wherein:

one of said two anti-reflection structures is a MYLAR film attached to said substrate.

7. An electronic weighing apparatus according to claim 5, wherein:

one of said two anti-reflection structures is a surface damper on said substrate with a multistrip coupler located between said surface damper and said SAW transmitter or receiver.

8. An electronic weighing apparatus according to claim 5, wherein:

one of said two anti-reflection structures is a layer of silicon oxide.

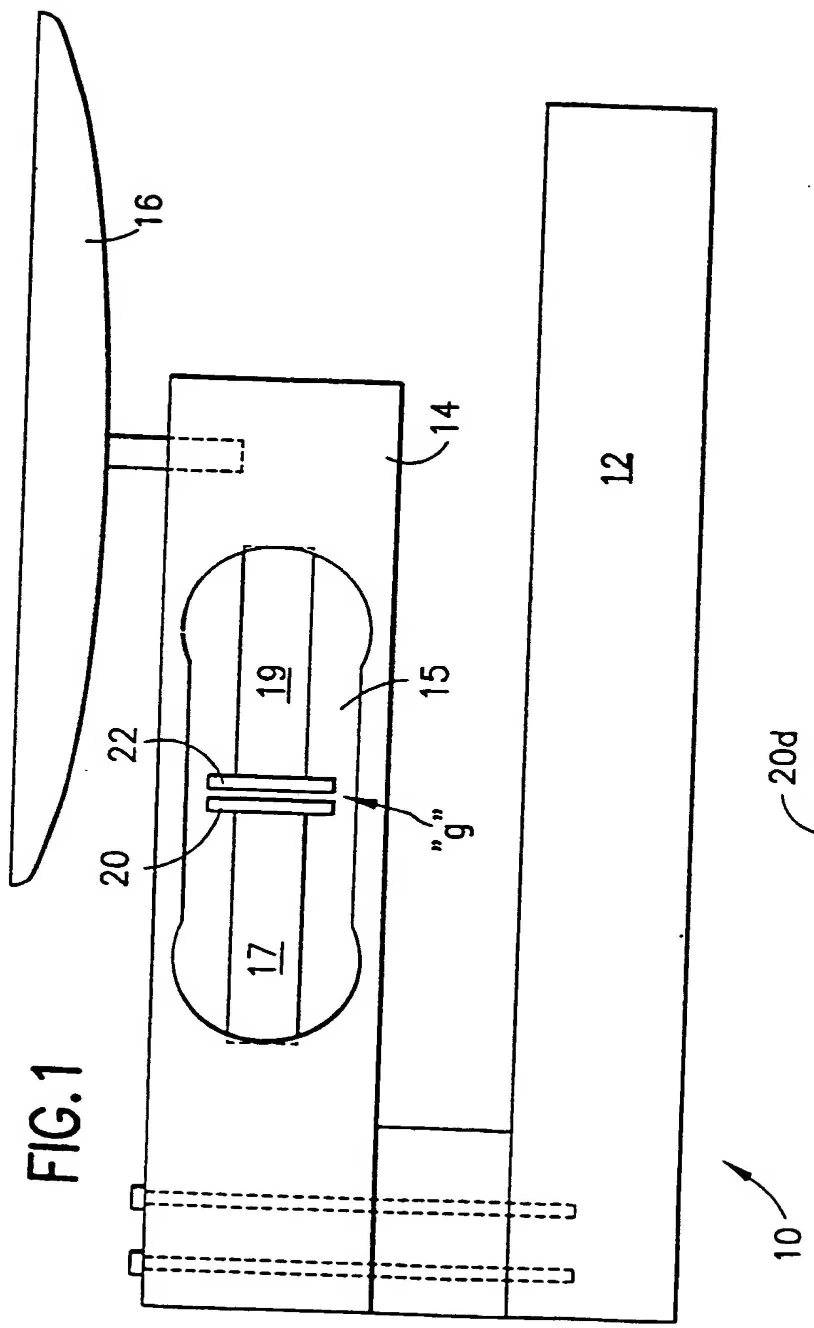


FIG.1

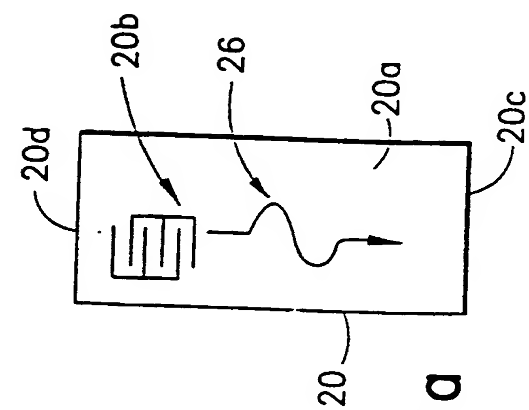


FIG.1a

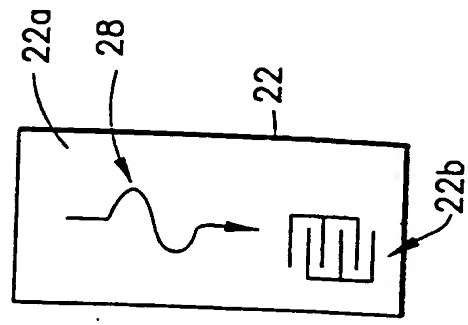


FIG.1b

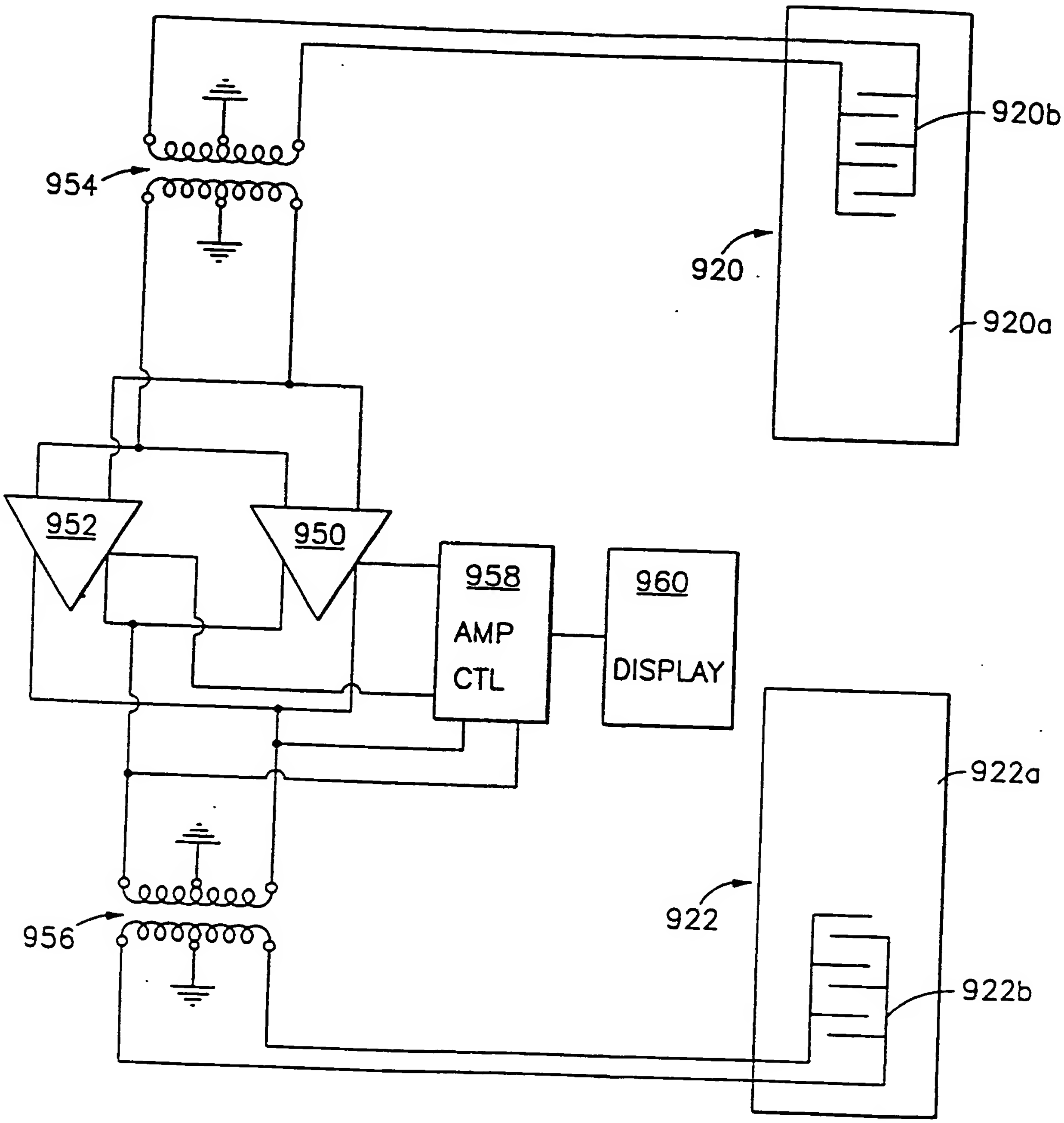

920b
954
920
920a
952
950
958
AMP
CTL
960
DISPLAY
922a
922
956
922b

FIG. 2

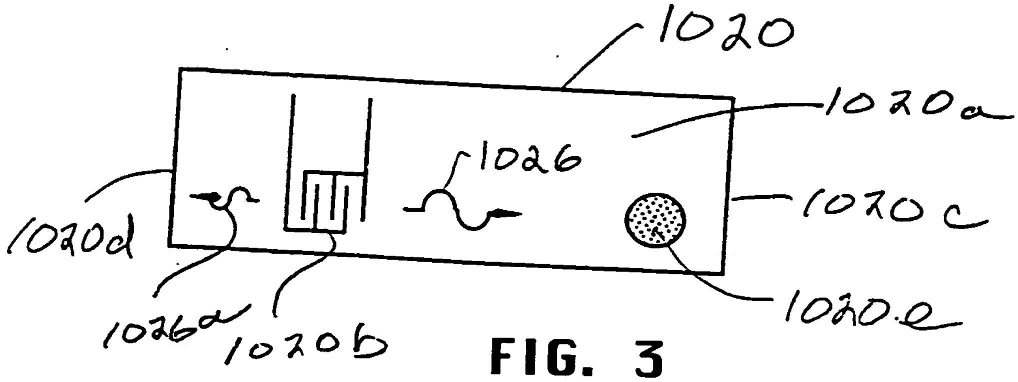


FIG. 3

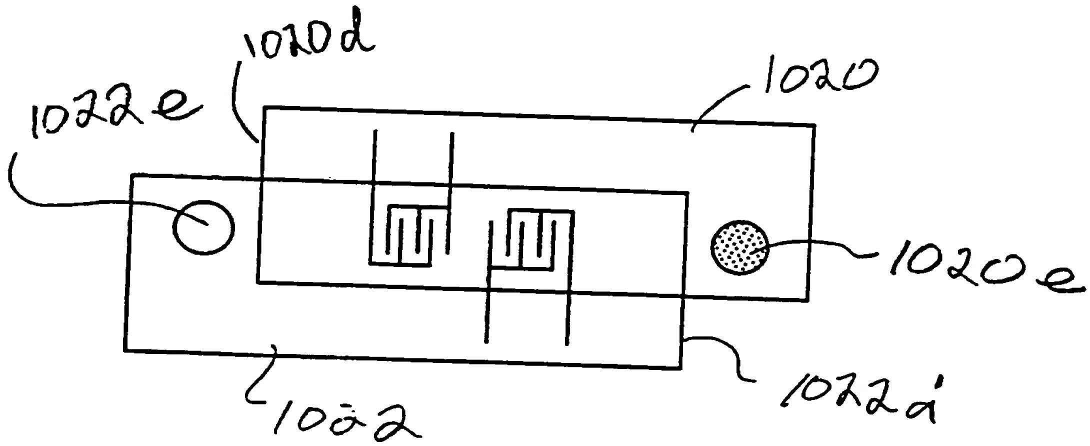


FIG. 4

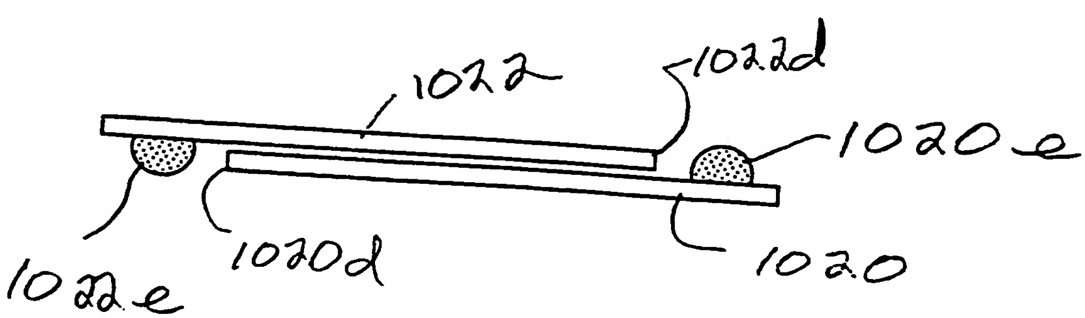


FIG. 5

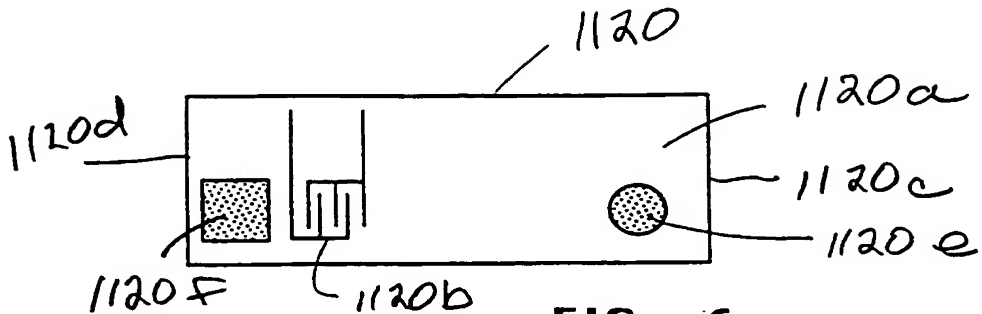


FIG. 6

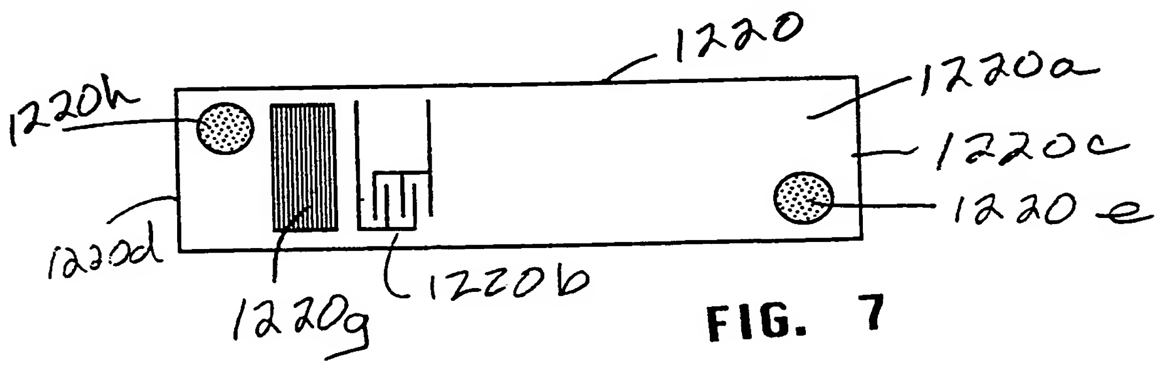


FIG. 7

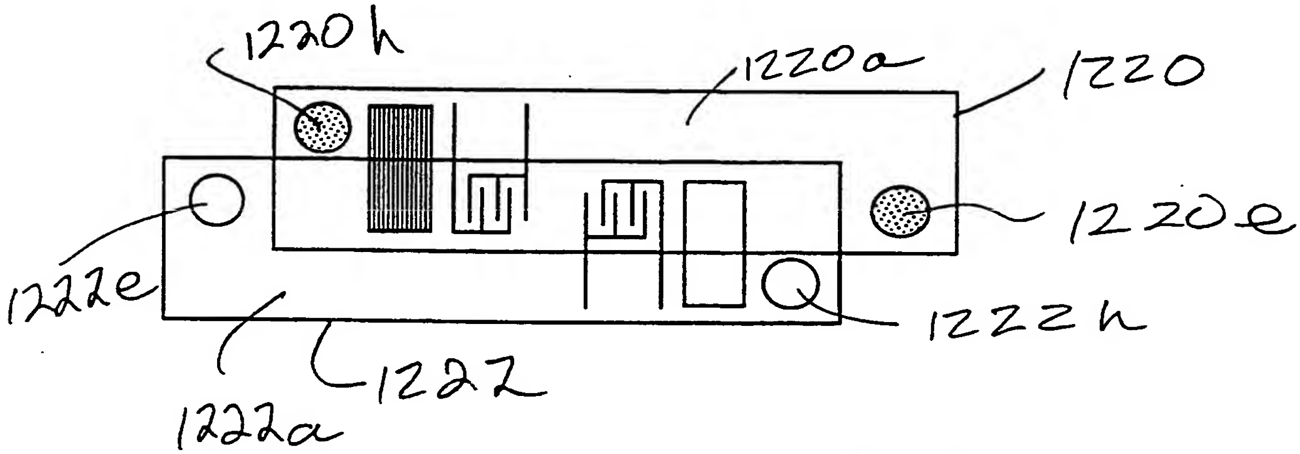


FIG. 8

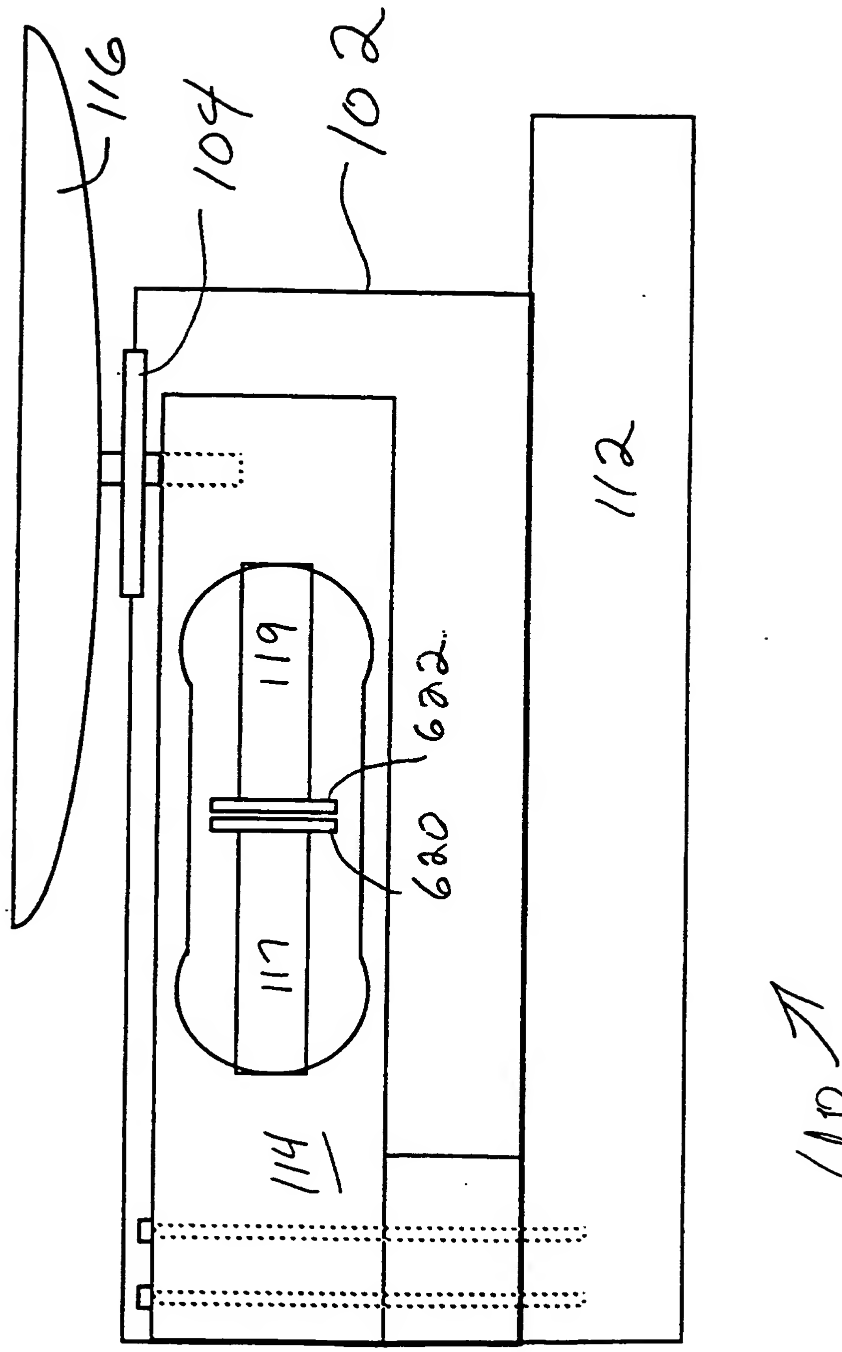


FIG. 9

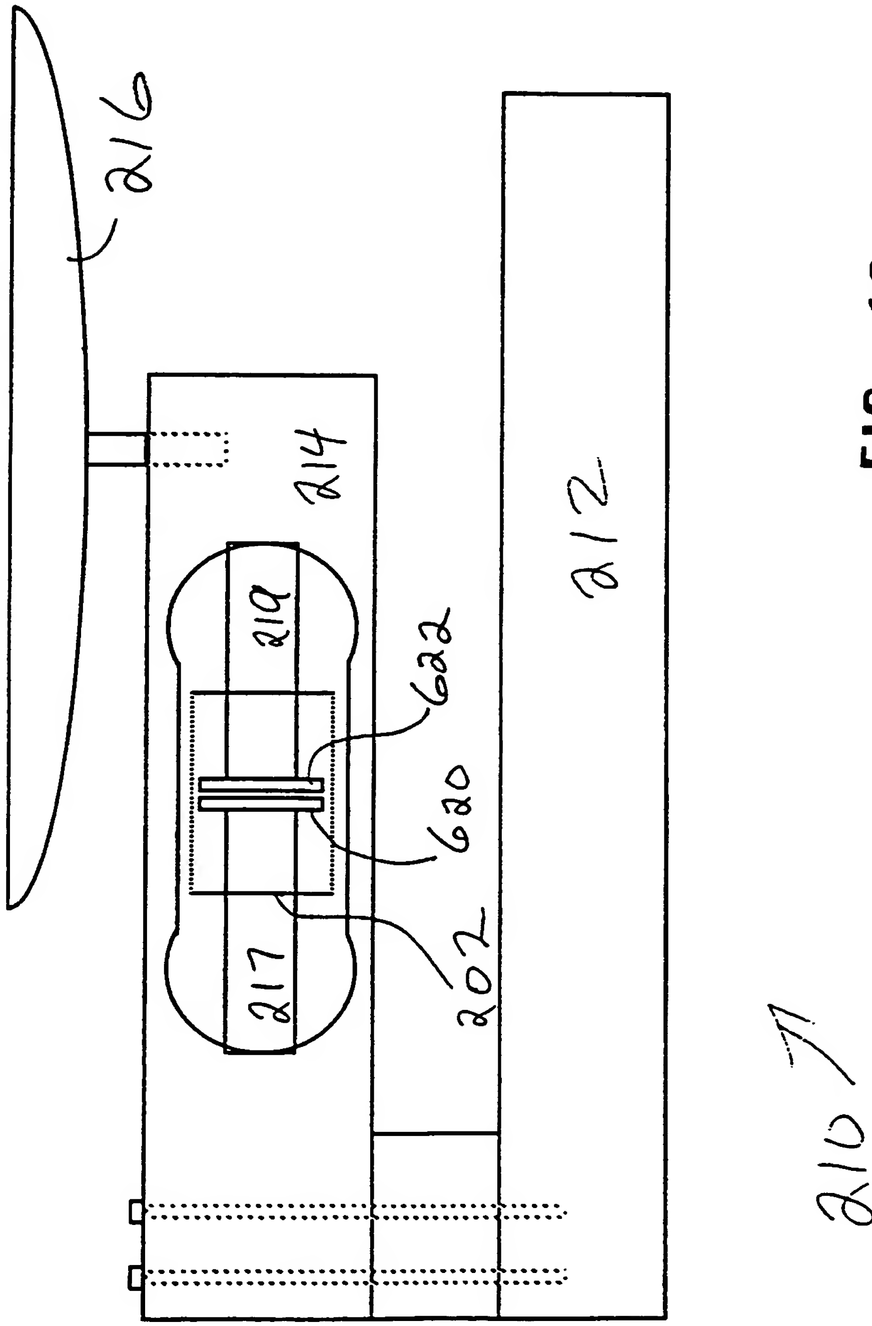


FIG. 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/15734

A. CLASSIFICATION OF SUBJECT MATTER
IPC(7) :G01G 3/14
US CL : 177/210R
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 177/210R, 210FP, 229; 73/862.59

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
None

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
None

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4,096,740 A (Sallee) 27 JUNE 1978 (27.06.1978), All	1-8
A	US 4,107,626 A (Kiewit) 15 AUGUST 1978 (15.08.1978), All	1-8
A	US 4,294,321 A (Wittlinger et al) 13 OCTOBER 1981 (13.10.1981), All	1-8
A	US 4,623,813 A (Naito et al) 18 NOVEMBER 1986 (18.11.1986), Col. 7, lines 14-32	1-4
A	US 4,858,145 A (Inoue et al) 15 AUGUST 1989 (15.08.1989), All	4
A	US 4,957,177 A (Hamilton) 18 SEPTEMBER 1990 (18.09.1990), All	1-3

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search 14 JULY 2000	Date of mailing of the international search report 06 OCT 2000
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer Deborah Perry-Lee RANDY GIBSON Telephone No. (703) 308-1782

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/15734

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,476,002 A (Bowers et al.) 19 DECEMBER 1995 (19.12.1995), All	1-8
A	US 5,663,531 A (Kats) 02 SEPTEMBER 1997 (02.09.1997), Claim 1	1-4
A	US 5,910,647 A (Kats et al) 08 JUNE 1999 (08.06.1999), Claim 14.	5-7

Claims:

1. An electronic weighing apparatus, comprising:

a) a displaceable elastic member means for receiving a load and being displaced by the load such that the displacement of said elastic member means is related to the weight of the load;

b) a first piezoelectric transducer having a first substrate and a first surface acoustic wave (SAW) transmitter, said first piezoelectric transducer being coupled to said elastic member;

c) a second piezoelectric transducer having a second substrate and a first SAW receiver, said second piezoelectric transducer being mounted in close proximity to said first piezoelectric transducer such that said displacement of said elastic member causes a corresponding displacement of one of said first and second piezoelectric transducers relative to the other;

d) a first amplifier having an input and an output, said input of said first amplifier being coupled to said first SAW receiver and said output of said first amplifier being coupled to said first SAW transmitter such that said first piezoelectric transducer, said first amplifier, and said second piezoelectric transducer form a first circuit having a first output;

e) processor means coupled to said output of said first amplifier; and

f) sealing means covering said first and second piezoelectric transducers for sealing out moisture and other contaminants, wherein

displacement of said elastic member means causes a displacement of one of said first and second piezoelectric transducers relative to the other and thereby changes said first output, and one of frequency, period, wavelength, and phase shift of said first output is used by said processor means to determine an indication of the weight of the load.

2. An electronic weighing apparatus according to claim 1, wherein:

said sealing means is an hermetic seal.

3. An electronic weighing apparatus according to claim 1, wherein:

said sealing means is a flexible sleeve.

4. An electronic weighing apparatus, comprising:

a) a displaceable elastic member means for receiving a load and being displaced by the load such that the displacement of said elastic member means is related to the weight of the load;

b) a first piezoelectric transducer having a first substrate and a first surface acoustic wave (SAW) transmitter, said first piezoelectric transducer being coupled to said elastic member;

c) a second piezoelectric transducer having a second substrate and a first SAW receiver, said second piezoelectric transducer being mounted in close proximity to said first piezoelectric transducer such that said displacement of said elastic member causes a corresponding displacement of one of said first and second piezoelectric transducers relative to the other;

d) a first amplifier having an input and an output, said input of said first amplifier being coupled to said first SAW receiver and said output of said first amplifier being coupled to said first SAW transmitter such that said first piezoelectric transducer, said first amplifier, and said second piezoelectric transducer form a first circuit having a first output;

e) processor means coupled to said output of said first amplifier; and

f) an hermetically sealed temperature sensor having an output coupled to said processor means, wherein

displacement of said elastic member means causes a displacement of one of said first and second piezoelectric transducers relative to the other and thereby changes said first output, and one of frequency, period, wavelength, and phase shift of said first output is used by said processor means to determine an indication of the weight of the load and said processor means uses said output of said hermetically sealed temperature sensor to compensate for the effects of temperature on said output of said first circuit.

5. An electronic weighing apparatus, comprising:

a) a displaceable elastic member means for receiving a load and being displaced by the load such that the displacement of said elastic member means is related to the weight of the load;

b) a first piezoelectric transducer having a first substrate and a first surface acoustic wave (SAW) transmitter, said first piezoelectric transducer being coupled to said elastic member;

c) a second piezoelectric transducer having a second substrate and a first SAW receiver, said second piezoelectric transducer being mounted in close proximity to said first piezoelectric transducer such that said displacement of said elastic member causes a corresponding displacement of one of said first and second piezoelectric transducers relative to the other;

d) a first amplifier having an input and an output, said input of said first amplifier being coupled to said first SAW receiver and said output of said first amplifier being coupled to said first SAW transmitter such that said first piezoelectric transducer, said first amplifier, and said second piezoelectric transducer form a first circuit having a first output; and

e) processor means coupled to said output of said first amplifier, wherein

one of said first and second piezoelectric transducers is provided with two anti-reflection structures to minimize reflection of surface acoustic waves, and

displacement of said elastic member means causes a displacement of one of said first and second piezoelectric transducers relative to the other and thereby changes said first output, and one of frequency, period, wavelength, and phase shift of said first output frequency is used by said processor means to determine an indication of the weight of the load.

6. An electronic weighing apparatus according to claim 5, wherein:

one of said two anti-reflection structures is a MYLAR film attached to said substrate.

7. An electronic weighing apparatus according to claim 5, wherein:

one of said two anti-reflection structures is a surface damper on said substrate with a multistrip coupler located between said surface damper and said SAW transmitter or receiver.

8. An electronic weighing apparatus according to claim 5, wherein:

one of said two anti-reflection structures is a layer of silicon oxide.

— *Before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
14 December 2000 (14.12.2000)

PCT

(10) International Publication Number
WO 00/75613 A1

(51) International Patent Classification⁷: G01G 3/14

(21) International Application Number: PCT/US00/15734

(22) International Filing Date: 8 June 2000 (08.06.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
09/327,707 8 June 1999 (08.06.1999) US

(63) Related by continuation (CON) or continuation-in-part (CIP) to earlier application:
US 09/327,707 (CON)
Filed on 8 June 1999 (08.06.1999)

(71) Applicant *(for all designated States except US)*: CIRCUITS AND SYSTEMS, INC. [US/US]; Foot of Second Street, East Rockaway, NY 11518 (US).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: KATS, Vyacheslav D. [RU/US]; 27 4th Avenue, East Rockaway, NY 11518 (US). GORDON, Arnold, S. [US/US]; 371 Yale Avenue, Woodmere, NY 11598 (US).

(74) Agent: GORDON, David, P.; 65 Woods End Road, Stamford, CT 06905 (US).

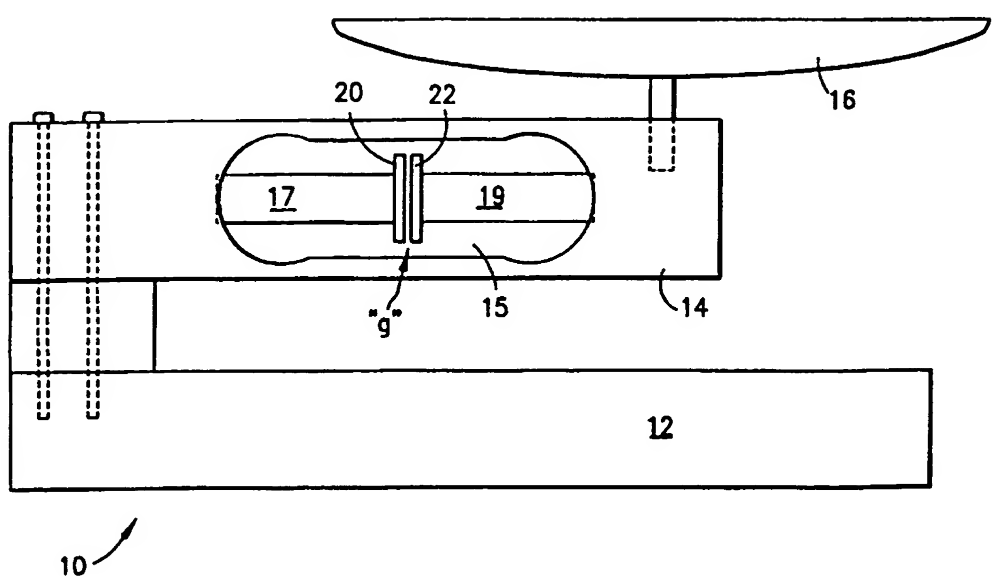
(81) Designated States *(national)*: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— *With international search report.*

[Continued on next page]

(54) Title: IMPROVED ELECTRONIC WEIGHING APPARATUS UTILIZING SURFACE ACOUSTIC WAVES



(57) Abstract: A weighing apparatus includes a base (12) supporting a cantilevered elastic member (14) bearing a load platform (16). The interior of the elastic member (14) is hollowed and is provided with first (20) and second (22) piezoelectric transducers mounted on respective opposed posts. The transducers are arranged substantially parallel to each other with a small gap between them and are coupled to an amplifier (950, 952) to form a "delay line" and a positive feedback loop, to form a natural oscillator.

WO 00/75613 A1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/15734

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :G01G 3/14
US CL : 177/210R
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 177/210R, 210FP, 229; 73/862.59

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

None

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

None

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4,096,740 A (Sallee) 27 JUNE 1978 (27.06.1978), All	1-8
A	US 4,107,626 A (Kiewit) 15 AUGUST 1978 (15.08.1978), All	1-8
A	US 4,294,321 A (Wittlinger et al) 13 OCTOBER 1981 (13.10.1981), All	1-8
A	US 4,623,813 A (Naito et al) 18 NOVEMBER 1986 (18.11.1986), Col. 7, lines 14-32	1-4
A	US 4,858,145 A (Inoue et al) 15 AUGUST 1989 (15.08.1989), All	4
A	US 4,957,177 A (Hamilton) 18 SEPTEMBER 1990 (18.09.1990), All	1-3

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 JULY 2000	06 OCT 2000

Name and mailing address of the ISA/US	Authorized officer
Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	RANDY GIBSON
Facsimile No. (703) 305-3230	Telephone No. (703) 308-1782

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/15734

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,476,002 A (Bowers et al.) 19 DECEMBER 1995 (19.12.1995), All	1-8
A	US 5,663,531 A (Kats) 02 SEPTEMBER 1997 (02.09.1997), Claim 1	1-4
A	US 5,910,647 A (Kats et al) 08 JUNE 1999 (08.06.1999), Claim 14.	5-7